CLAIMS

What is claimed is:

1. A method of building a model for a physical plant in the presence of noise comprising:

(a) initializing the model of the physical plant, wherein the model is characterized by a parameter vector;

(b) estimating outputs using the model;

(c) computing a composite cost comprising a weighted average of a squared error between the estimated output from the model and an actual output of the physical plant, and a squared derivative of the error;

(d) determining a step-size and a model update direction; and

(e) updating the model of the physical plant, wherein said updating step is dependent upon the step size.

2. The method of claim 1, further comprising repeating said steps (b)-(e) for subsequent iterations.

3. The method of claim 1, said step (c) further comprising using a cost function defined by $J(\mathbf{w}) = E(\hat{e}_k^2) + \beta E(\hat{\dot{e}}_k^2)$ to compute the error.

4. The method of claim 1, said step (a) further comprising:

setting the parameter vector $\mathbf{w}_k$ to an initial set of values;

bounding the step size η by $0 < \eta < \dfrac{2\left|E(\hat{e}_k^2 - 0.5\hat{\dot{e}}_k^2)\right|}{E\left[\left\|\hat{e}_k\hat{\mathbf{x}}_k - 0.5\hat{\dot{e}}_k\hat{\dot{\mathbf{x}}}_k\right\|^2\right]}$; and

setting a lag value to be greater than or equal to a number of parameters in a physical system including the physical plant.

5. The method of claim 1, said step (a) further comprising setting a β value to be substantially equal to -0.5.

6. The method of claim 1, said step (a) further comprising setting a β value to be equal to -

0.5.

7. The method of claim 1, wherein the parameter vector is represented as $\mathbf{w}_k$, said step (e) further comprising updating the parameter vector according to $\mathbf{w}_{k+1} = \mathbf{w}_k + \eta sign(\hat{e}_k^2 + \beta \dot{\hat{e}}_k^2)(\hat{e}_k \hat{\mathbf{x}}_k + \beta \dot{\hat{e}}_k \dot{\hat{\mathbf{x}}}_k)$.

8. A system for building a model for a physical plant in the presence of noise comprising:

(a) means for initializing the model of the physical plant, wherein the model is characterized by a parameter vector;

(b) means for estimating outputs using the model;

(c) means for computing a composite cost comprising a weighted average of a squared error between the estimated output from the model and an actual output of the physical plant, and a squared derivative of the error;

(d) means for determining a step size and a model direction; and

(f) means for updating the model of the physical plant, wherein operation of the updating means is dependent upon the step size.

9. The system of claim 8, further comprising means for causing each of said means (b)-(e) to operate in an iterative fashion.

10. The system of claim 8, said means (c) further comprising means for using a cost function defined by $J(\mathbf{w}) = E(\hat{e}_k^2) + \beta E(\dot{\hat{e}}_k^2)$ to compute the error.

11. The system of claim 8, said means (a) further comprising:

means for setting the parameter vector $\mathbf{w}_k$ to an initial set of values;

means for bounding the step size η by $0 < \eta < \dfrac{2\left|E(\hat{e}_k^2 - 0.5\dot{\hat{e}}_k^2)\right|}{E\left[\left\|\hat{e}_k \hat{\mathbf{x}}_k - 0.5\dot{\hat{e}}_k \dot{\hat{\mathbf{x}}}_k\right\|^2\right]}$; and

means for setting a lag value to be greater than or equal to a number of parameters in a physical system including the physical plant.

12. The system of claim 8, said means (a) further comprising means for setting a β value to be substantially equal to -0.5.

13. The system of claim 8, said means (a) further comprising means for setting a β value to be equal to -0.5.

14. The system of claim 8, wherein the parameter vector is represented as $\mathbf{w}_k$, said means (e) further comprising means for updating the parameter vector according to $\mathbf{w}_{k+1} = \mathbf{w}_k + \eta sign(\hat{e}_k^2 + \beta\hat{\dot{e}}_k^2)(\hat{e}_k\hat{\mathbf{x}}_k + \beta\hat{\dot{e}}_k\hat{\dot{\mathbf{x}}}_k)$.

15. A machine readable storage having stored thereon, a computer program having a plurality of code sections, said code sections executable by a machine for causing the machine to build a model of a physical plant in the presence of noise comprising the steps of:

(a) initializing the model of the physical plant, wherein the model is characterized by a parameter vector;

(b) estimating outputs using the model;

(c) computing a composite cost comprising a weighted average of a squared error between the estimated output from the model and an actual output of the physical plant, and a squared derivative of the error;

(d) determining a step size and a model update direction; and

(e) updating the model of the physical plant, wherein said updating step is dependent upon the step size.

16. The machine readable storage of claim 15, further comprising repeating said steps (b)-(e) for subsequent iterations.

17. The machine readable storage of claim 15, said step (c) further comprising using a cost function defined by $J(\mathbf{w}) = E(\hat{e}_k^2) + \beta E(\hat{\dot{e}}_k^2)$ to compute the error.

18. The machine readable storage of claim 15, said step (a) further comprising:

setting the parameter vector $\mathbf{w}_k$ to an initial set of values;

bounding the step size η by $0 < \eta < \dfrac{2\left|E(\hat{e}_k^2 - 0.5\hat{\hat{e}}_k^2)\right|}{E\left[\left\|\hat{e}_k\hat{\mathbf{x}}_k - 0.5\hat{\hat{e}}_k\hat{\hat{\mathbf{x}}}_k\right\|^2\right]}$; and

setting a lag value to be greater than or equal to a number of parameters in the physical system.

19. The machine readable storage of claim 15, said step (a) further comprising setting a β value to be substantially equal to -0.5.

20. The machine readable storage of claim 15, said step (a) further comprising setting a β value to be equal to -0.5.

21. The machine readable storage of claim 15, wherein the parameter vector is represented as $\mathbf{w}_k$, said step (e) further comprising updating the parameter vector according to $\mathbf{w}_{k+1} = \mathbf{w}_k + \eta sign(\hat{e}_k^2 + \beta\hat{\hat{e}}_k^2)(\hat{e}_k\hat{\mathbf{x}}_k + \beta\hat{\hat{e}}_k\hat{\hat{\mathbf{x}}}_k)$.

22. A method of building a model for a physical plant in the presence of noise comprising:

(a) initializing the model of the physical plant and an inverse Hessian matrix, wherein the model is characterized by a parameter vector;

(b) determining a Kalman gain;

(c) estimating an output of the model;

(d) computing an error vector between the estimated output from the model and an actual output of the physical plant;

(e) updating the model of the physical plant; and

(f) updating the inverse Hessian matrix.

23. The method of claim 22, further comprising repeating said steps (b)-(f) for further iterations.

24. The method of claim 22, said step (a) further comprising initializing the inverse Hessian matrix $\mathbf{Z}_0^{-1}$ according to $\mathbf{Z}_0^{-1} = c\mathbf{I}$.

25. The method of claim 22, said step (b) further comprising:

computing a matrix $\mathbf{B}$ according to $\mathbf{B} = [(2\beta\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L}) \quad \hat{\mathbf{x}}_k]$; and

computing a matrix $\mathbf{D}$ according to $\mathbf{D} = [\hat{\mathbf{x}}_k \quad (\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L})]$.

26. The method of claim 25, wherein the Kalman gain is represented as $\boldsymbol{\kappa}_k$, said step (b) further comprising calculating the Kalman gain according to $\boldsymbol{\kappa}_k = \mathbf{Z}_{k-1}^{-1}\mathbf{B}\left(\mathbf{I}_{2x2} + \mathbf{D}^T\mathbf{Z}_{k-1}^{-1}\mathbf{B}\right)^{-1}$.

27. The method of claim 22, said step (c) further comprising:

calculating an output y_k according to $y_k = \hat{\mathbf{x}}_k^T\mathbf{w}_{k-1}$; and

calculating an output y_{k-L} according to $y_{k-L} = \hat{\mathbf{x}}_{k-L}^T\mathbf{w}_{k-1}$.

28. The method of claim 22, wherein the error vector is represented as $\mathbf{e}_k$, said step (d) further comprising calculating the error according to

$$\mathbf{e}_k = \begin{bmatrix} d_k - y_k \\ d_k - y_k - \beta(d_{k-L} - y_{k-L}) \end{bmatrix} = \begin{bmatrix} e_k \\ e_k - \beta e_{k-L} \end{bmatrix}.$$

29. The method of claim 22, wherein the parameter vector characterizing the model is represented as $\mathbf{w}_k$, said step (e) further comprising updating the parameter vector according to $\mathbf{w}_k = \mathbf{w}_{k-1} + \boldsymbol{\kappa}_k\mathbf{e}_k$.

30. The method of claim 22, wherein the inverse Hessian matrix is represented as $\mathbf{Z}_k^{-1}$, said step (f) further comprising calculating the updated inverse Hessian matrix according to $\mathbf{Z}_k^{-1} = \mathbf{Z}_{k-1}^{-1} - \boldsymbol{\kappa}_k\mathbf{D}^T\mathbf{Z}_{k-1}^{-1}$.

31. The method of claim 22, wherein the error vector of said step (d) comprises at least two quantities weighted by β.

32. The method of claim 31, wherein β is equal to 0.5.

33. The method of claim 31, wherein β is substantially equal to -0.5.

34. A system for building a model for a physical plant in the presence of noise comprising:

(a) means for initializing the model of the physical plant and an inverse Hessian matrix, wherein the model is characterized by a parameter vector;

(b) means for determining a Kalman gain;

(c) means for estimating an output of the model;

(d) means for computing an error vector between the estimated output from the model and an actual output of the physical plant;

(e) means for updating the model of the physical plant; and

(f) means for updating the inverse Hessian matrix.

35. The system of claim 34, further comprising means for causing each of said means (b)-(f) to operate for further iterations.

36. The system of claim 34, said means (a) further comprising means for initializing the inverse Hessian matrix $\mathbf{Z}_0^{-1}$ according to $\mathbf{Z}_0^{-1} = c\mathbf{I}$.

37. The system of claim 36, said means (b) further comprising:

means for computing a matrix $\mathbf{B}$ according to $\mathbf{B} = [(2\beta\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L}) \quad \hat{\mathbf{x}}_k]$; and

means for computing a matrix $\mathbb{D}$ according to $\mathbb{D} = [\hat{\mathbf{x}}_k \quad (\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L})]$.

38. The system of claim 34, wherein the Kalman gain is represented as $\boldsymbol{\kappa}_k$, said means (b) further comprising means for calculating the Kalman gain according to $\boldsymbol{\kappa}_k = \mathbf{Z}_{k-1}^{-1}\mathbf{B}\left(\mathbf{I}_{2x2} + \mathbb{D}^T\mathbf{Z}_{k-1}^{-1}\mathbf{B}\right)^{-1}$.

39. The system of claim 34, said means (c) further comprising:

means for calculating an output y_k according to $y_k = \hat{\mathbf{x}}_k^T \mathbf{w}_{k-1}$; and

means for calculating an output y_{k-L} according to $y_{k-L} = \hat{\mathbf{x}}_{k-L}^T \mathbf{w}_{k-1}$.

40. The system of claim 34, wherein the error vector is represented as $\mathbf{e}_k$, said means (d) further comprising means for calculating the error according to

$$\mathbf{e}_k = \begin{bmatrix} d_k - y_k \\ d_k - y_k - \beta(d_{k-L} - y_{k-L}) \end{bmatrix} = \begin{bmatrix} e_k \\ e_k - \beta e_{k-L} \end{bmatrix}.$$

41. The system of claim 34, wherein the parameter vector characterizing the model is represented as $\mathbf{w}_k$, said means (e) further comprising means for updating the parameter vector according to $\mathbf{w}_k = \mathbf{w}_{k-1} + \boldsymbol{\kappa}_k \mathbf{e}_k$.

42. The system of claim 34, wherein the inverse Hessian matrix is represented as $\mathbf{Z}_k^{-1}$, said means (f) further comprising means for calculating the updated inverse Hessian matrix according to $\mathbf{Z}_k^{-1} = \mathbf{Z}_{k-1}^{-1} - \boldsymbol{\kappa}_k \mathbf{D}^T \mathbf{Z}_{k-1}^{-1}$.

43. The system of claim 34, wherein the error vector of said means (d) comprises at least two quantities weighted by β.

44. The system of claim 43, wherein β is equal to 0.5.

45. The system of claim 43, wherein β is substantially equal to -0.5.

46. A machine readable storage having stored thereon, a computer program having a plurality of code sections, said code sections executable by a machine for causing the machine to build a model for a physical plant in the presence of noise comprising the steps of:

(a) initializing the model of the physical plant and an inverse Hessian matrix, wherein

the model is characterized by a parameter vector;

(b) determining a Kalman gain;

(c) estimating an output of the model;

(d) computing an error vector between the estimated output from the model and an actual output of the physical plant;

(e) updating the model of the physical plant; and

(f) updating the inverse Hessian matrix.

47. The machine readable storage of claim 46, further comprising repeating said steps (b)-(f) for further iterations.

48. The machine readable storage of claim 46, said step (a) further comprising initializing the inverse Hessian matrix $\mathbf{Z}_0^{-1}$ according to $\mathbf{Z}_0^{-1} = c\mathbb{I}$.

49. The machine readable storage of claim 48, said step (b) further comprising:

computing a matrix $\mathbf{B}$ according to $\mathbf{B} = [(2\beta\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L}) \quad \hat{\mathbf{x}}_k]$; and

computing a matrix $\mathbf{D}$ according to $\mathbf{D} = [\hat{\mathbf{x}}_k \quad (\hat{\mathbf{x}}_k - \beta\hat{\mathbf{x}}_{k-L})]$.

50. The machine readable storage of claim 46, wherein the Kalman gain is represented as $\boldsymbol{\kappa}_k$, said step (b) further comprising calculating the Kalman gain according to $\boldsymbol{\kappa}_k = \mathbf{Z}_{k-1}^{-1}\mathbf{B}\left(\mathbb{I}_{2x2} + \mathbf{D}^T\mathbf{Z}_{k-1}^{-1}\mathbf{B}\right)^{-1}$.

51. The machine readable storage of claim 46, said step (c) further comprising:

calculating an output y_k according to $y_k = \hat{\mathbf{x}}_k^T\mathbf{w}_{k-1}$; and

calculating an output y_{k-L} according to $y_{k-L} = \hat{\mathbf{x}}_{k-L}^T\mathbf{w}_{k-1}$.

52. The machine readable storage of claim 46, wherein the error vector is represented as $\mathbf{e}_k$, said step (d) further comprising calculating the error according to

$$\mathbf{e}_k = \begin{bmatrix} d_k - y_k \\ d_k - y_k - \beta(d_{k-L} - y_{k-L}) \end{bmatrix} = \begin{bmatrix} e_k \\ e_k - \beta e_{k-L} \end{bmatrix}.$$

53. The machine readable storage of claim 46, wherein the parameter vector characterizing the model is represented as $\mathbf{w}_k$, said step (e) further comprising updating the parameter vector according to $\mathbf{w}_k = \mathbf{w}_{k-1} + \boldsymbol{\kappa}_k \mathbf{e}_k$.

54. The machine readable storage of claim 46, wherein the inverse Hessian matrix is represented as $\mathbf{Z}_k^{-1}$, said step (f) further comprising calculating the updated inverse Hessian matrix according to $\mathbf{Z}_k^{-1} = \mathbf{Z}_{k-1}^{-1} - \boldsymbol{\kappa}_k \mathbf{D}^T \mathbf{Z}_{k-1}^{-1}$.

55. The machine readable storage of claim 46, wherein the error vector of said step (d) comprises at least two quantities weighted by β.

56. The machine readable storage of claim 55, wherein β is equal to 0.5.

57. The machine readable storage of claim 55, wherein β is substantially equal to -0.5.